The largest engineering economics mistake ever made?

Ignoring green vehicle and biofuel impacts on crude oil prices.

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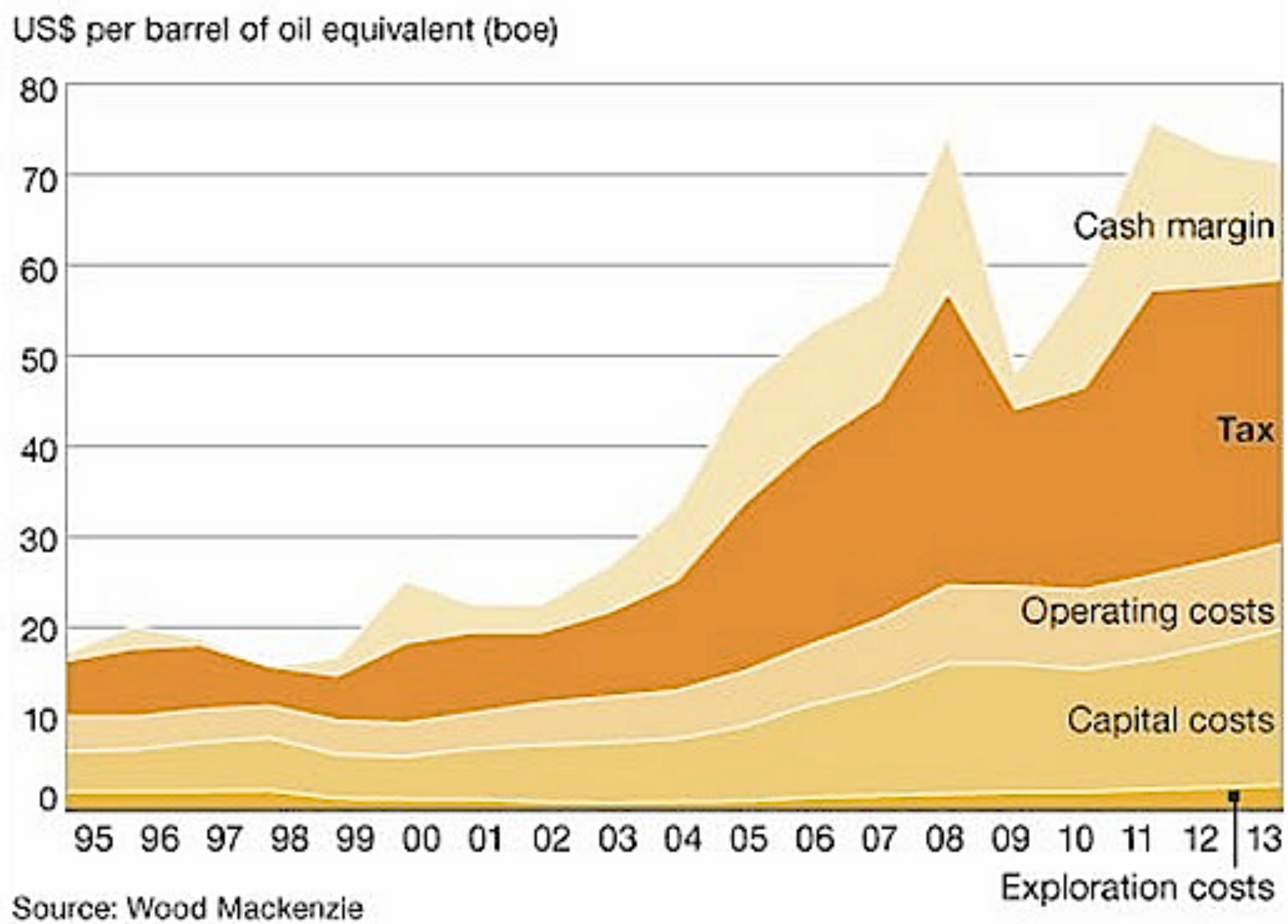
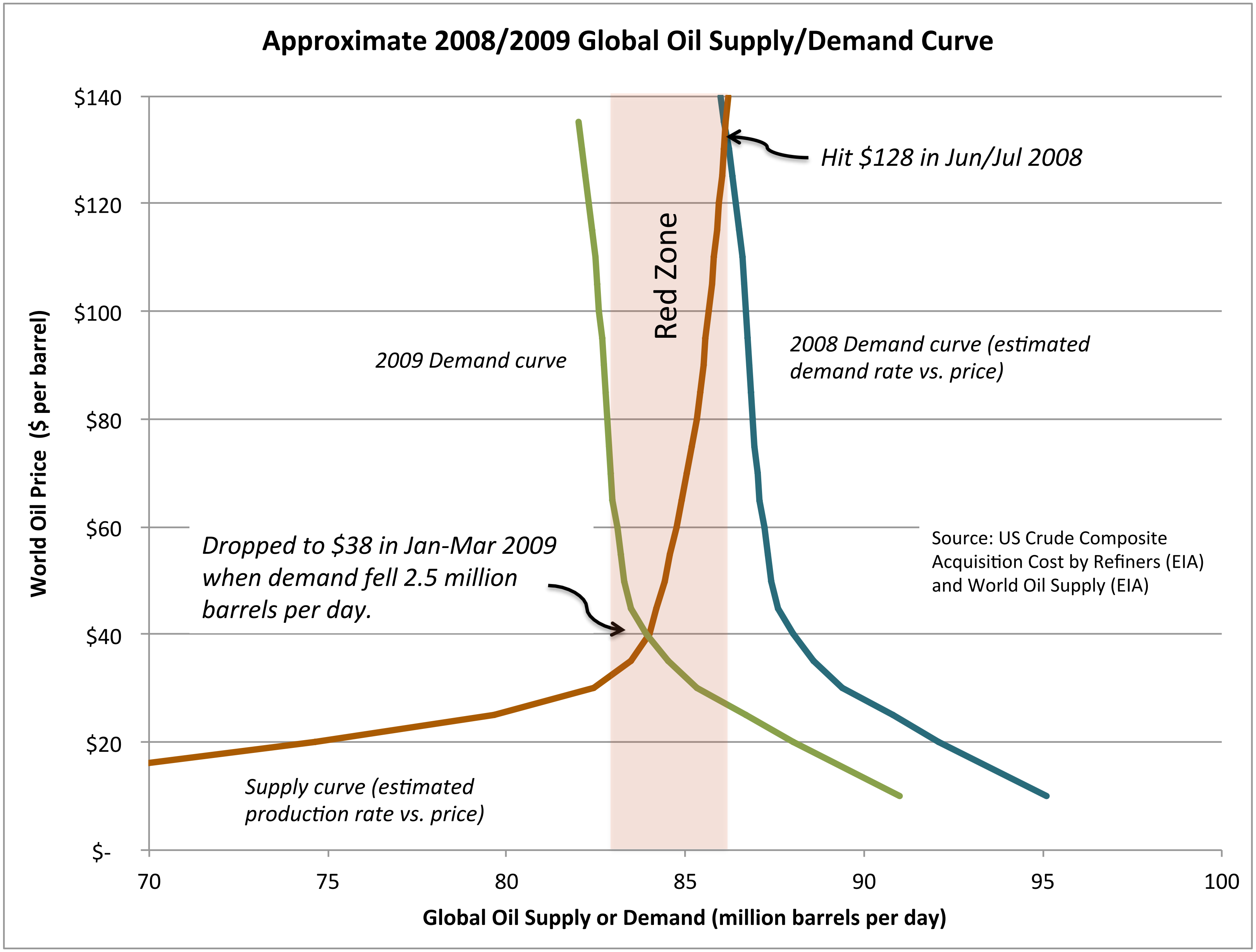
Oil Production Rate Limits Causes Oil Price Sensitivity to Demand
Part 1

- Almost all oil production costs less than $30 per barrel to produce
  - Following chart shows production costs of about $30 per barrel; the “tax” shown in the chart goes to the country or company that owns the oil resource.
  - Exploration finding costs, plus the capital portion of lift costs comprise over $20 per barrel.
  - Almost all fields in production in the world today, have already recovered these expenditures (exploration costs and capital cost portion of lift costs).
  - Operating costs generally run less than $10 per barrel, although stripper wells, and high cost production such as tar sands, have op costs comprising a higher portion of the lift costs.
  - Dropping the oil price to $40 from current levels (48-month moving average is in the $85-90 range) by reducing demand, wouldn’t shut-in much production due to price declining below lift costs.
  - Only when the price falls below $30, would significant production shut-in due to costs.
  - Reducing demand levels by 20%, would likely drive oil prices below $20 per barrel, without serious OPEC contravention to keep prices higher (OPEC controls 40% of the oil supply).
  - If global demand declined enough (20-30%), the price of oil could collapse to the level of the op cost portion of lift costs, approximately $10 per barrel.

Side notes:

- A collapse to $10-20 per barrel, doesn’t work to the best interests of most stakeholders, but would stall the tar sands production ramp.
- A large drop in oil price, creates an opportunity to add a tax on petroleum, that could fund green vehicles, biofuels, energy efficiency investments, even green power subsidies, and still lower customer costs.

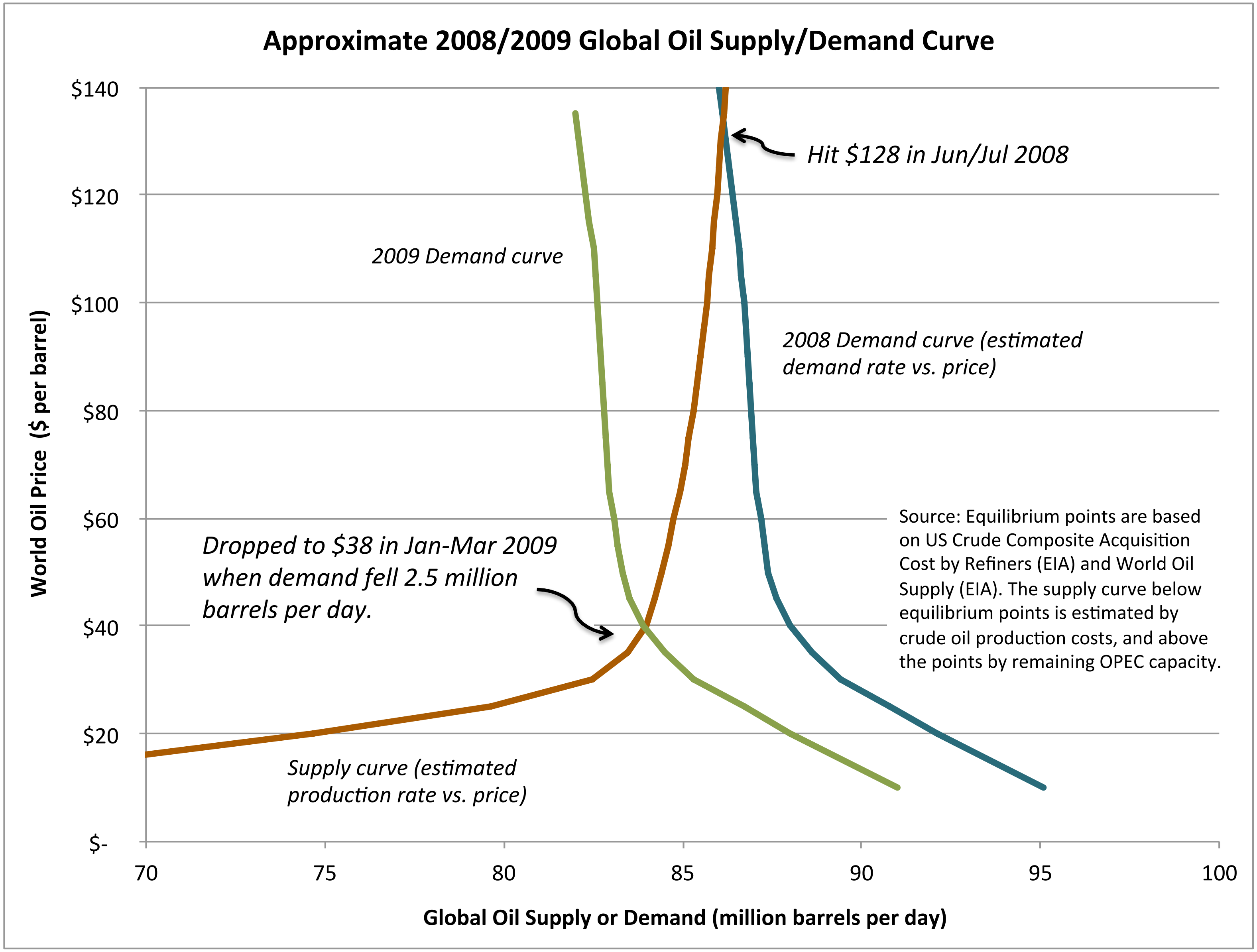

US$ per barrel of oil equivalent (boe)
80
70
60
50
40
30
20
10
0
Cash margin
Tax
Operating costs
Capital costs
95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13
Exploration costs
Source: Wood Mackenzie



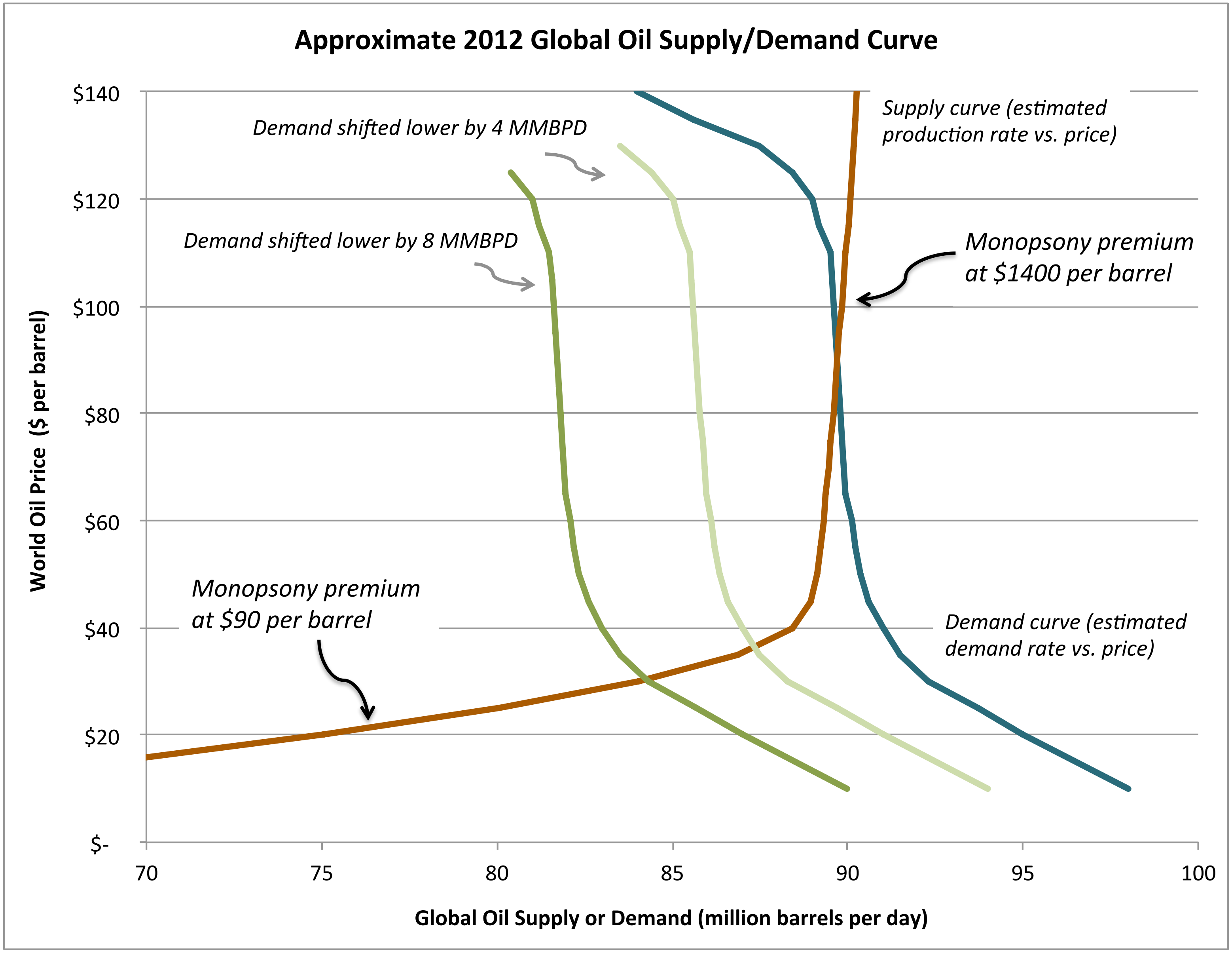
Approximate 2008/2009 Global Oil Supply/Demand Curve
$140
$120
$100
$80
$60
$40
$20
$-
World Oil Price ($ per barrel)
70
75
80
85
90
95
100
Global Oil Supply or Demand (million barrels per day)
Red Zone
Hit $128 in Jun/Jul 2008
2009 Demand curve
2008 Demand curve (estimated
demand rate vs. price)
Dropped to $38 in Jan-Mar 2009
when demand fell 2.5 million
barrels per day.
Source: US Crude Composite
Acquisition Cost by Refiners (EIA)
and World Oil Supply (EIA)
Supply curve (estimated
production rate vs. price)

Oil Production Rate Limits Causes Oil Price Sensitivity to Demand Part 2

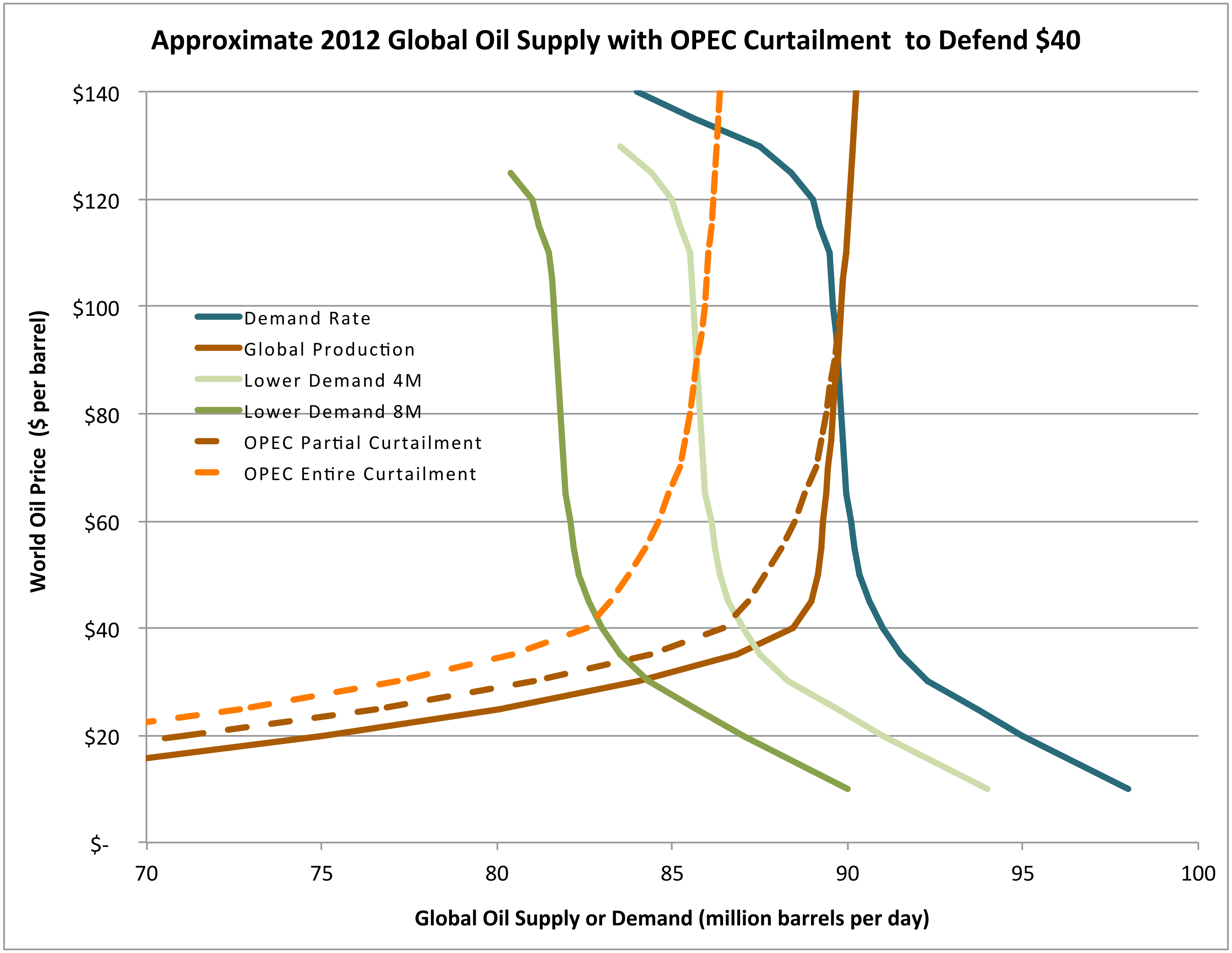
- Increasing demand has pushed production rates into the vertical price climbing interval of the supply curve, in spite of increased production capacity.
  - Global oil production is limited by the capability of the oilfields to produce; if the wells are drawn too hard, eventual recovered reserves decline due to saltwater incursion, or damage to the formation
  - Production rate can be increased in the short-term by drilling infill wells, or working over wells; but the last five years of high prices have likely depleted the potential to increase production rate by these methods.
  - As increasing demand pushed the price up, OPEC decreased their production curtailment, but mostly since late 2006, OPEC has produced at capacity (although new fields developed, increasing OPEC production rate from 32 million to 36 million BPD)
  - OPEC + US + Russian + W. African production increases drove global oil production higher from 78 million in 2002 to over a rate over 90 million BPD by mid-2013.
  - Although the production rate increased due to new field development, demand increased faster, eating up surplus OPEC (Saudi) production capacity.
  - This pushed the production rate into the "red zone" just below maximum global production rate (within 4 million BPD), and eventually pushed prices much higher (up the hockey stick blade).
- Connecting the two sectional intervals of the supply curve, between the horizontal handle section (flat due to the low prices needed to shut-in production), and the vertical blade section (vertical due to inability to increase production beyond capability), is the shoulder section where the slope depends on decisions by OPEC to curtail production.



Approximate 2008/2009 Global Oil Supply/Demand Curve
$140
$120
$100
$80
$60
$40
$20
$-
World Oil Price ($ per barrel)
70
75
80
85
90
95
100
Global Oil Supply or Demand (million barrels per day)
Hit $128 in Jun/Jul 2008
2009 Demand curve
2008 Demand curve (estimated demand rate vs. price)
Dropped to $38 in Jan-Mar 2009 when demand fell 2.5 million barrels per day.
Source: Equilibrium points are based on US Crude Composite Acquisition Cost by Refiners (EIA) and World Oil Supply (EIA). The supply curve below equilibrium points is estimated by crude oil production costs, and above the points by remaining OPEC capacity.
Supply curve (estimated production rate vs. price)



Approximate 2012 Global Oil Supply/Demand Curve
$140
$120
$100
$80
$60
$40
$20
$-
World Oil Price ($ per barrel)
70
75
80
85
90
95
100
Global Oil Supply or Demand (million barrels per day)
Demand shifted lower by 4 MMBPD
Demand shifted lower by 8 MMBPD
Supply curve (estimated production rate vs. price)
Monopsony premium at $1400 per barrel
Monopsony premium at $90 per barrel
Demand curve (estimated demand rate vs. price)



Approximate 2012 Global Oil Supply with OPEC Curtailment to Defend $40
$140
$120
$100
$80
$60
$40
$20
$-
70
75
80
85
90
95
100
World Oil Price ($ per barrel)
Global Oil Supply or Demand (million barrels per day)
Demand Rate
Global Production
Lower Demand 4M
Lower Demand 8M
OPEC Partial Curtailment
OPEC Entire Curtailment

Oil Price Elasticity of Demand: Short-Term versus Long-Term (20 years)

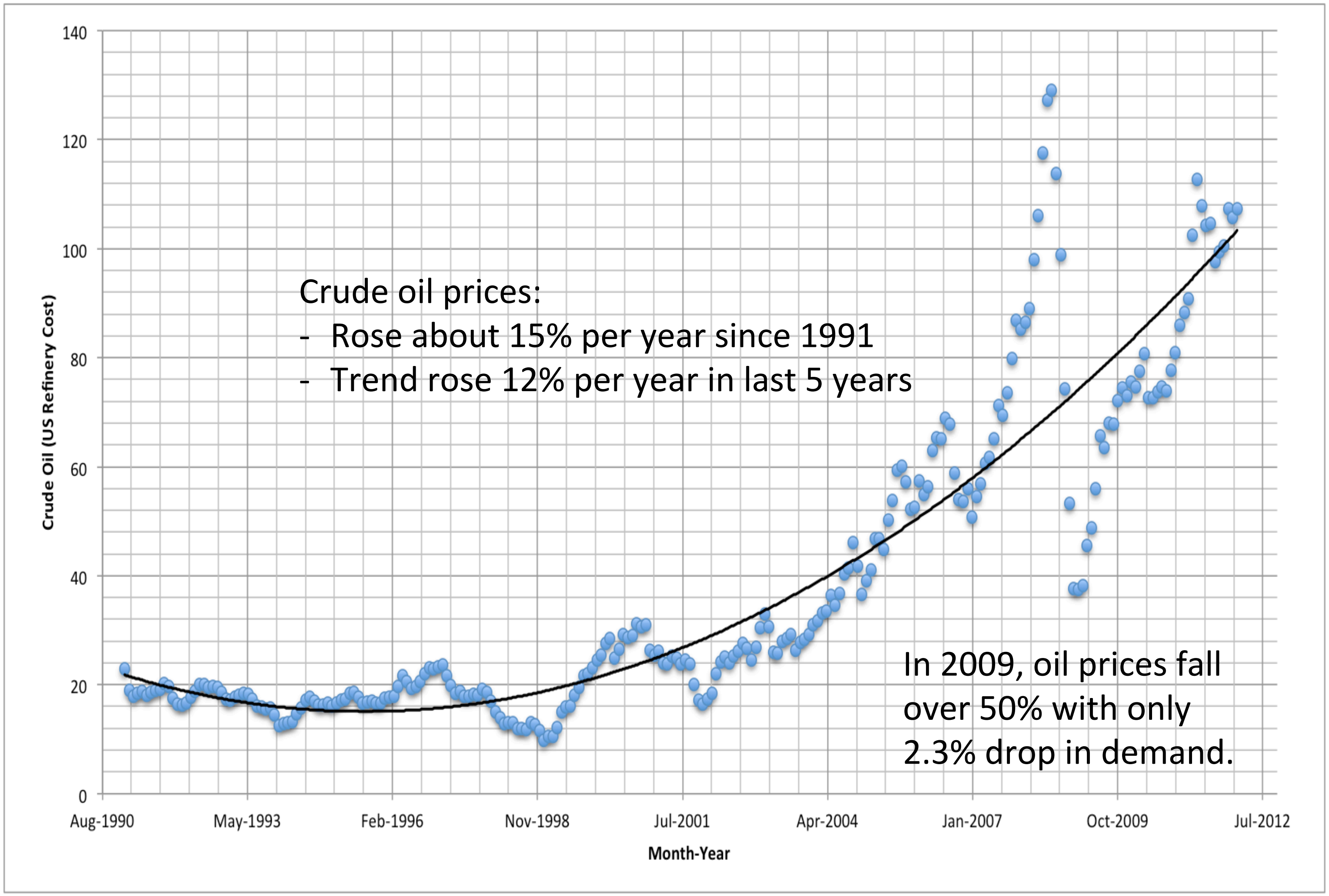
Table 3.1. Oil Demand Price and Income Elasticities
(Subsample, 1990–2009)

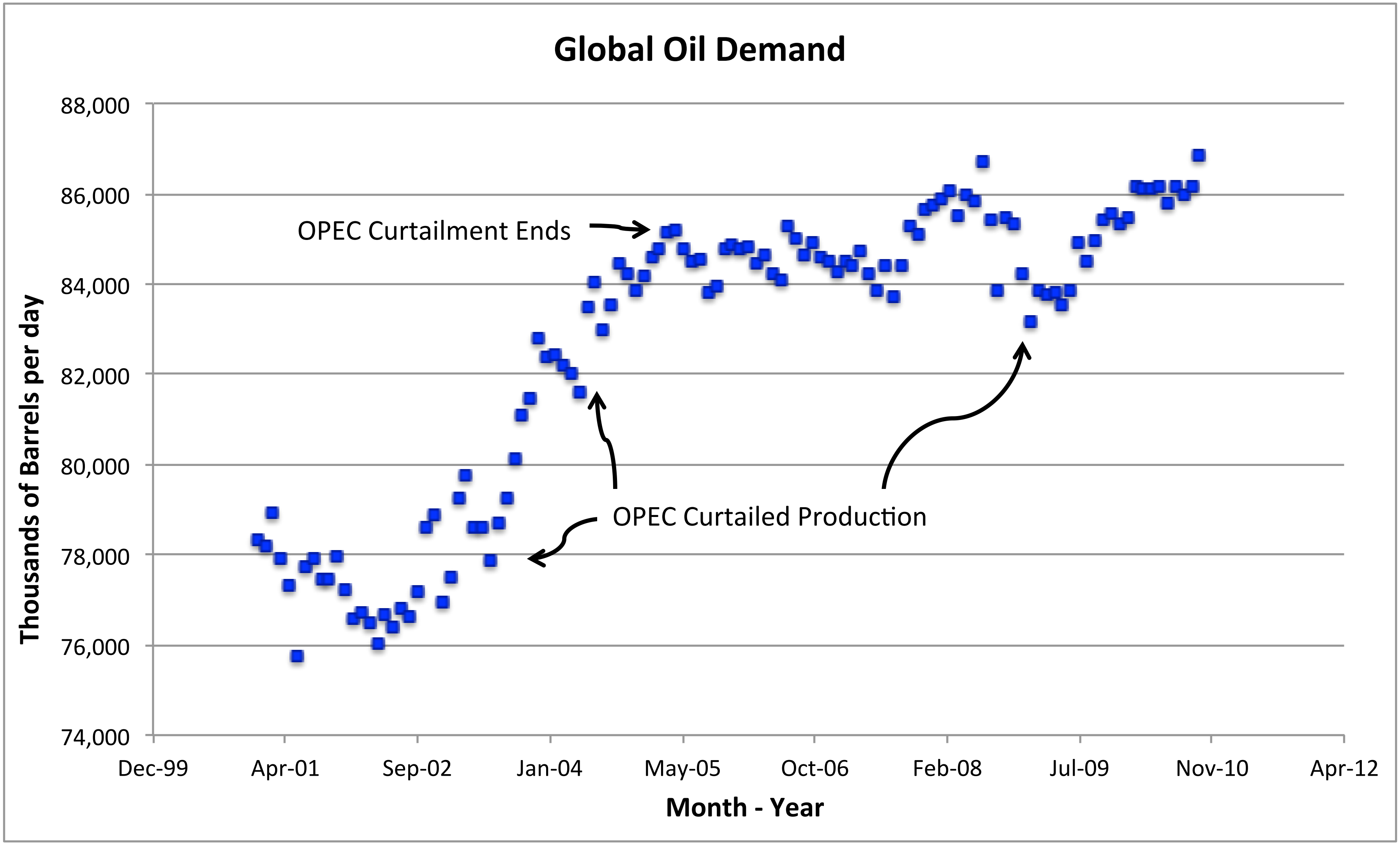
	Short-Term Elasticity		Long-Term Elasticity	
	Price	Income	Price	Income
Combined OECD[1] and Non-OECD	–0.019	0.685	–0.072	0.294
	[–0.028, –0.009]	[0.562, 0.808]	[–0.113, –0.032]	[0.128, 0.452]
OECD	–0.025	0.671	–0.093	0.243
	[–0.035, –0.015]	[0.548, 0.793]	[–0.128, –0.057]	[0.092, 0.383]
Non-OECD	–0.007	0.711	–0.035	0.385
	[–0.016, 0.002]	[0.586, 0.836]	[–0.087, 0.013]	[0.193, 0.577]

Source: IMF staff calculations.

Note: Median elasticities and confidence intervals showing 10th and 90th percentile of the distribution in brackets are estimated by Monte Carlo simulations. Long-term elasticities are calculated using a 20-year horizon.

Crude Oil Prices: Since 1990

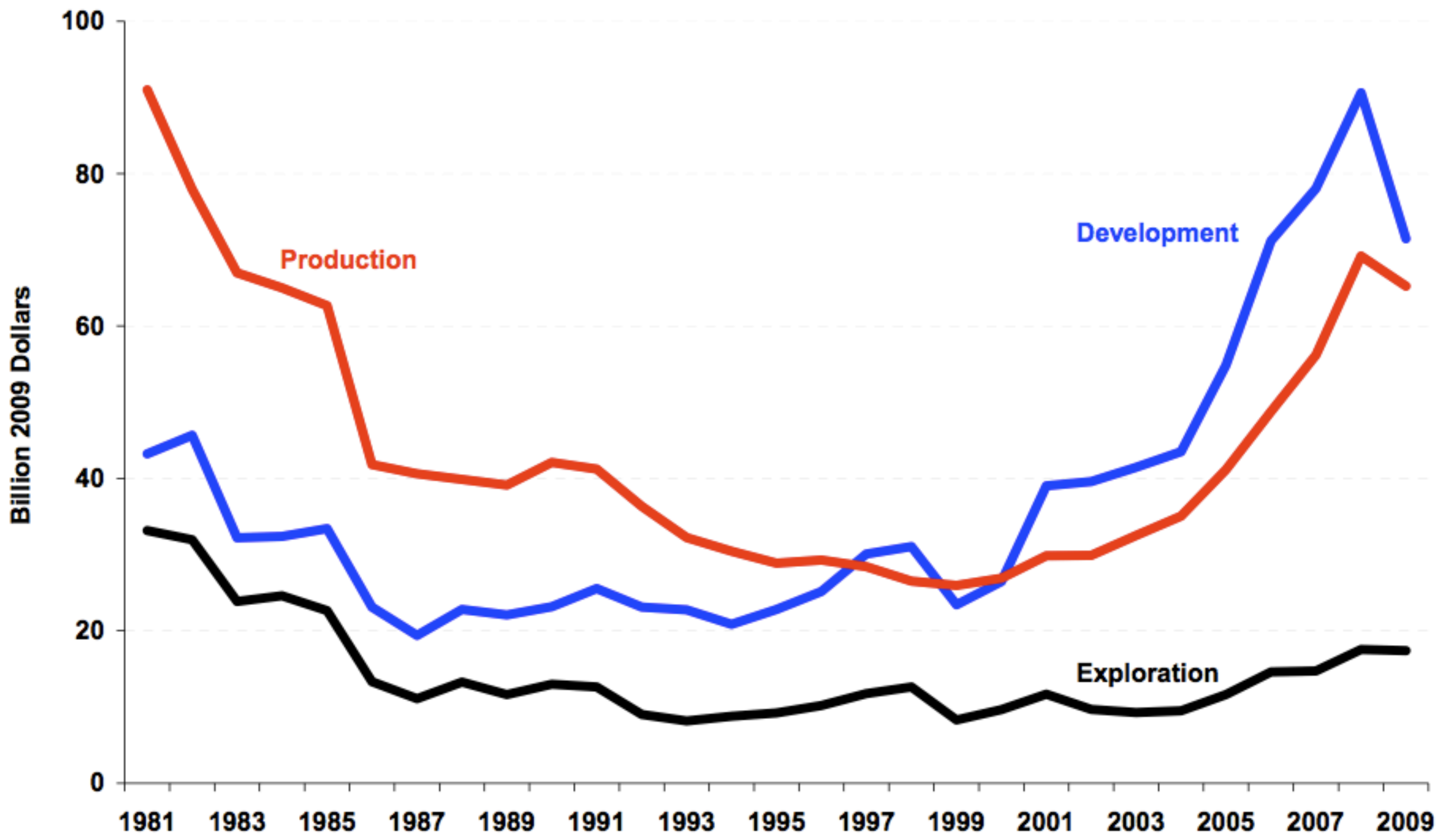



Global Oil Demand
88,000
86,000
84,000
82,000
80,000
78,000
76,000
74,000
Thousands of Barrels per day
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Month - Year
OPEC Curtailment Ends
OPEC Curtailed Production

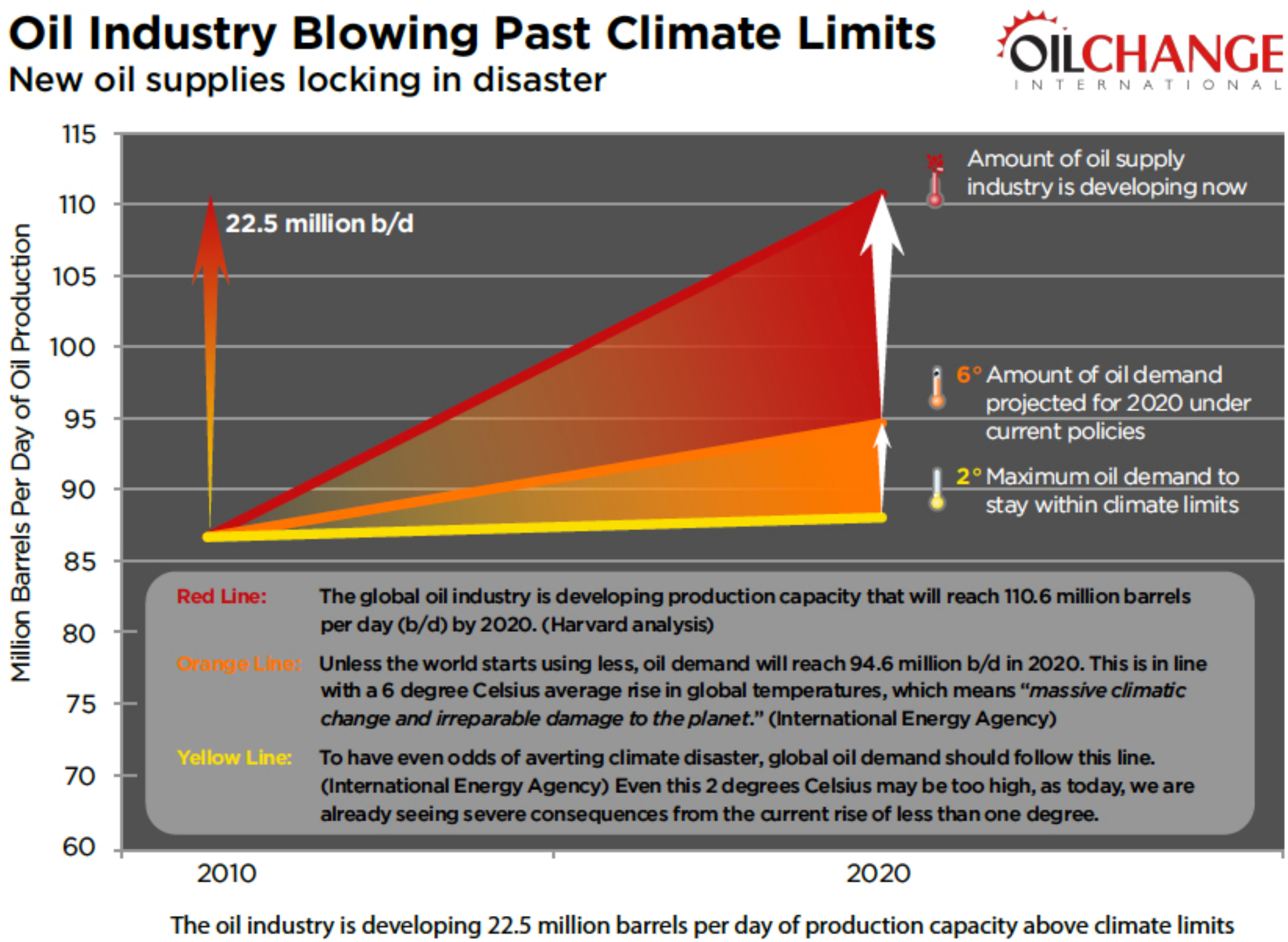
Oil Company Expenditures

(from EIA report, “Performance Measures of Major Energy Producers 2009)

Figure 11. FRS Worldwide Expenditures for Exploration, Development, and Production, 1981-2009



Source: U.S. Energy Information Administration, Form EIA-28 (Financial Reporting System).


Oil Industry Blowing Past Climate Limits
New oil supplies locking in disaster
OILCHANGE INTERNATIONAL
Million Barrels Per Day of Oil Production
115
110
105
100
95
90
85
80
75
70
60
2010
2020
22.5 million b/d
Amount of oil supply industry is developing now
6° Amount of oil demand projected for 2020 under current policies
2° Maximum oil demand to stay within climate limits
Red Line: The global oil industry is developing production capacity that will reach 110.6 million barrels per day (b/d) by 2020. (Harvard analysis)
Orange Line: Unless the world starts using less, oil demand will reach 94.6 million b/d in 2020. This is in line with a 6 degree Celsius average rise in global temperatures, which means "massive climatic change and irreparable damage to the planet." (International Energy Agency)
Yellow Line: To have even odds of averting climate disaster, global oil demand should follow this line. (International Energy Agency) Even this 2 degrees Celsius may be too high, as today, we are already seeing severe consequences from the current rise of less than one degree.
The oil industry is developing 22.5 million barrels per day of production capacity above climate limits

Calculating Oil Price Sensitivity to Demand

- Monopsony Premium calculated by Leiby et.al. (1997) and Leiby et.al. (2007)
  - Premium was based on oil market data from 1992-1995 and 2004-2005 timeframes when OPEC had significant additional production capability.
  - Oil prices in those periods was around $20 per barrel, and $40 per barrel, much closer to oil production costs than recent price range of $80-$110.
  - Estimated supply/demand curves for 2008/2009 and 2012 show a very different situation of market oil price versus oil production costs than earlier periods.
  - Monopsony oil price premium was based only on US imported oil premium costs, ignoring mis-allocation of capital to the oil industry instead of vehicle manufacturers and biofuel producers.
- Oil Price Elasticity of Demand published by the IMF report on crude oil markets
  - Inverse of price elasticity gives the oil price sensitivity to demand changes.
  - IMF estimates the short term elasticity of demand at negative 0.019, meaning that the first 1% decline in global demand would cause global prices to drop over 50% at the margin.
  - Highest IMF short term elasticity estimate of negative 0.028 means the global oil price falls almost 36% for the first 1% decline in demand.
  - IMF estimates the longer term elasticity (20 years) at negative 0.072, meaning that each 1% decline in demand would cause global prices to drop almost 14%.
- Skibo's analysis, uses an elasticity of negative 0.06 (16.7%) for the first percent of decline, with lower price sensitivity to demand used once the price drops near $40 per barrel.

Examples of how to calculate monopsony estimates from the Supply(production) curve using the slope of the curve over an incremental production curve interval.	
Supply Curve "hockey stick handle" section:	
Estimate the change in price for a given incremental change in demand.	Calculate $11 drop in price for 10 million BPD change from 82 to 72 million BPD. This is $1.10/bbl for each million BPD change.
Apply the price change to the amount of oil used to calculate the relevant monopsony premium.	Use $1.10/bbl for one million BPD decline in demand, applied to the global oil demand of (82-1) million BPD = $89M per day. **Global Monopsony Premium = $89 per barrel**
For US imported oil, use the change in global oil price and apply only to remaining US imported oil volume to estimate total decreased oil costs, then divide by the reduction in import volumes.	Use $1.10/bbl for one million BPD decline in demand, applied to the imported oil demand of (10-1) million BPD = $10M per day. **US Import Monopsony Premium = $10 per barrel**
Supply Curve "hockey stick blade" section	
Estimate the change in price for an incremental change in demand on the blade.	Calculate a $50 per barrel price drop for a 2 million BPD change from 86 million BPD to 84 million BPD. This is $25/bbl for each million BPD change.
Apply the price change to the amount of oil used to calculate the relevant monopsony premium.	Use $25/bbl applied to (89-1) million BPD to get $2200M per day. **Global Monopsony Premium = $2200 per barrel**
For US imported oil, use the change in global oil price and apply only to remaining US imported oil volume to estimate total decreased oil costs, then divide by the reduction in import volumes.	Use $25/bbl for one million BPD decline in demand, applied to the imported oil demand of (9-1) million BPD = $200M per day. **US Import Monopsony Premium = $200 per barrel**

Accuracy Problems with Michalek et.al. (2011) Use of Monopsony Oil Premiums (Errors Analyzing Crude Oil Market Pricing, and Production Rates/ Production Costs).

1. Analysis in MI11 ignores change in crude oil market between 2004/2005 period, and the period starting in mid-2006 to the present.
   a) In 2004/2005 OPEC had significant additional production capacity (4+ million BPD).
   b) Since late 2006, OPEC has produced at or near capacity.
   c) Crude oil price at the equilibrium point (S=D) has increased to 3x-4x production costs, and caused a rationing premium.
   d) Leiby estimated **$10/bbl** ($2010) US imported oil monopsony premium; now would get **$200/bbl (20X)**.
   e) Skibo uses a price sensitivity to demand equivalent to $126/barrel (12.6X) monopsony premium for first 5% of decline.

2. Analysis in MI11 assumes no foreign PHEV/BEV substitution; Leiby only considered unilateral action.
   a) If foreign countries substitute one EV for every EV US substitutes (1:1), then the monopsony premium estimates for US imported oil doubles(20X MI11 estimate) to **$400/bbl**.
   b) If foreign countries substitutes two EVs for every EV US substitutes (2:1) increases the monopsony premium for US imported oil increases to 60X MI11 estimate to **$600/bbl**; and 3: 1 increases 80X to $800/bbl.
   c) Reaching agreements on substitution with other oil importers substantially leverages our collective monopsony power.

3. Analysis in MI11 ignores windfall profits accruing to US domestic production => Causes misallocation of capital to oil industry instead of green vehicle and biofuel industries.
   a) Currently imports comprise 8 million BPD of 19 million BPD demand, so the additional premium paid on domestic oil increases the total monopsony premium on US oil demand by another 2.4X to **$950 to $1420** per barrel.
   b) This causes an additional $200B annually collected by domestic oil producers, that could go to vehicle manufacturers or biofuel producers instead, if global demand fell 10% due to substitution.

4. Analysis in MI11 ignores the variable value of the monopsony oil premium due to substitution as green vehicles penetrate into the vehicle fleet.
   a) The Supply curve isn't a straight line over the interval of 5-10% reduced demand by 2020 advocated by Skibo.
   b) US import monopsony premium starts in the range **$200 to $380** per barrel, then falls below **$100** after a 5-10% decline.

Various Estimates of Oil Premiums Paid by Oil Products Customers Due to Rationing Premium In the Market Oil Price Since 2006 ($/barrel)				
Time Period	2004 through 2005	2008 / 2009	2012 Estimate	5 yr. Forecast
<u>US Import Monopsony Premium</u>	$10	$380	$200	$126
With foreign substitution				
➢ Match US 1:1	$20	$760	$400	$252
➢ Match US 2:1	$30	$1140	$600	$378
➢ Match US 3:1	$40	$1520	$800	$504
Based on these import levels =>	*10 million BPD*	*9 million BPD*	*8 million BPD*	*8 million BPD*
<u>US Domestic + Import Oil Cost Premium</u>	$19-21	$720	$475	$300
With foreign substitution				
➢ Match US 1:1	$40	$1520	**$950**	$600
➢ Match US 2:1	$60	$2280	**$1425**	$900
➢ Match US 3:1	$80	$3040	$1900	$1200
Based on US demand of 19 million BPD.				
<u>OECD Oil Cost Premium</u>				
With foreign substitution				
➢ Match US 1:1	$49	$1760	**$980**	**$620**
➢ Match US 2:1	$48	$1730	$960	$605
Based on OECD demand of 46 million BPD.				
<u>Hypothetical Global Oil Cost Premium</u>	$80	$3150	$2250	$1420
Based on these global demand levels =>	83	86	90	Varies

Global Participation Matches 1:1 US/Canadian Fleet PHEV/EV Substitution

Adapted from Michalek et.al. 2011

Table S26. Lifetime ownership costs (*$2010 per vehicle lifetime)*

	CV	HEV	PHEV20	PHEV60	BEV
Base Vehicle Cost	23019	24800	25666	25729	20497
Initial Battery Cost	0	2068	2632	8730	31953
Battery Replacement Cost	0	0	0	0	0
Gasoline Cost	12386	8847	7189	6226	0
Electricity Cost	0	0	788	2314	5282
Scheduled Maintenance	4380	3962	3235	3235	2232
Charger/installation	0	0	1200	2400	2400
Net Cost	39786	39677	40709	48635	62364
Lifetime Oil Premium @22¢/gal.	829	592	481	417	0

Fleet Penetration Case	**Base**	(to achieve 22 cents/gallon gasoline price drop)			
Single Vehicle Lifetime Oil Premium	829	592	481	417	0
US/Can. Fleet Penetration Needed		4.4%	3.0%	2.5%	**1.25%**
Ratio of CV/EV		22	33	39	79
CV Fleet Oil Cost Savings per EV deployed		17539	26530	31714	65491
Total Savings by Other US/Can. Oil Customers per EV		7517	11370	13592	28068
Adjusted Net Cost	39786	14621	2809	3329	(31195)
Net Cost (Savings) for Foreign Oil Customers per foreign EV		(38913)	(77611)	(92585)	(228027)
Net Cost (Savings) of Global Consumers per EV Deployed	39786	(12146)	(37401)	(44628)	(129611)

Global Participation Matches 2:1 US/Canadian Fleet PHEV/EV Substitution

Adapted from Michalek et.al. 2011

Table S26. Lifetime ownership costs (*$2010 per vehicle lifetime)*

	CV	HEV	PHEV20	PHEV60	BEV
Base Vehicle Cost	23019	24800	25666	25729	20497
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Electricity Cost	0	0	788	2314	5282
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Charger/installation	0	0	1200	2400	2400
Net Cost	39786	39677	40709	48635	62364
Lifetime Oil Premium @22¢/gal.	829	592	481	417	0

Fleet Penetration Case	**Base**	(based on 22 cents/gallon gasoline price drop)			
Single Vehicle Lifetime Oil Premium	829	592	481	417	0
US/Can. Fleet Penetration Needed		2.9%	2.0%	1.7%	**0.84%**
Ratio of CV/EV		33	49	58	118
CV Fleet Oil Cost Savings per EV deployed		26793	40119	47802	97861
Total Savings by Other US/Can. Oil Customers per EV		11483	17194	20486	41941
Adjusted Net Cost	39786	1401	(16603)	(19653)	(77438)
Net Cost (Savings) for Foreign Oil Customers per foreign EV		(20659)	(49062)	(58104)	(154911)
Net Cost to Global Consumers per Global EV Deployed	39786	(13306)	(38242)	(45287)	(129086)

Conclusion: A Decline in Oil Demand would Reduce the Oil Production Rate Significantly Below the Production Limit and Cause a Large Oil Price Drop

- Increasing demand has pushed production rates into a “Red Zone” where the oil price climbed to levels 3x-4x production costs.
- Incremental cost of oil to customers exceeds $600 per barrel, and could be as high as $1500 per barrel, due to the increased price on existing purchases caused by the extra demand.
- The higher price gives US domestic oil producers an additional $200B annually, with some of these windfall profits invested to push to higher levels of high cost oil production.
- Alternatively, a significant portion of customer payments for oil products, could be directed into green vehicles, biofuels, or energy efficiency investments, to reduce oil demand.
- Re-allocating the capital flow would result in lower oil prices, and the resulting savings could fund the investments to reduce oil demand.
- Each time a conventional vehicle is purchased instead of a green vehicle, the sum of the misallocated purchase cost plus the oil cost premium incurred is approximately $120k.
- Not deploying 8 million green or biofuel vehicles per year is a suboptimal investment decision causing $1 trillion of misdirected cash flow during these vehicle lifetimes.
- Reaching this level of green vehicle sales as rapidly as possible, reduces the $1 trillion annual opportunity cost of delaying the deployment.

Important Questions:

Why didn't the oil industry engineers and economists discover this and propose action?

Why didn't the green vehicle industry, or the biofuel industry, discover this and propose action?

What is the best way to ramp green vehicles into the vehicle fleet and increase the production and use of biofuels?

Why did "Drill baby, drill!" become the only acceptable answer to addressing rising oil prices in a dysfunctional oil market?

Is oil industry financial support of Republican politicians (especially Tea Party), tied to blocking green energy policies and reducing financial impacts on their industry that would be caused by green vehicle substitution?